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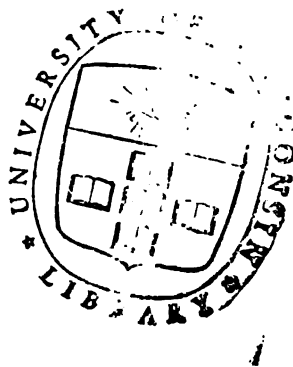
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AGRICULTURE OF LA CROSSE COUNTY
AND THE
DRIFTLESS REGION OF WISCONSIN
THE PHOSPHOROUS DETERMINATION (APPENDED)

By
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A thesis submitted for the degree of
MASTER OF SCIENCE
In Agriculture

UNIVERSITY OF WISCONSIN
1912

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OCT 17 1933
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INTRODUCTION

A study of the agriculture and soils of southwestern Wisconsin reveals problems of management, rotation, and general farm practice which are distinctive in the state. This is so because this so-called driftless area is the only portion of the state where the natural development of topography and soils has not been interrupted or altered by glaciation. The topography now developed consists essentially of an elevated table land, which has been deeply dissected, resulting in an intricate system of steep, narrow valleys separated by level to rolling ridges.

The soils of the driftless area are residual and loessial and conform closely to the underlying rock which is largely limestone with some sandstone. The glacial action of the remainder of the state has tended to smooth and soften down the previously developed erosional topography, rounding off the ridges and filling up the valleys. The soils, also, of the glaciated portion of the state have been modified greatly from their residual condition. Under the influence of the successively advancing and retreating ice sheets and the accompanying large amounts of water, the soils have been transported, mixed and partially re-assort-

ed.

The soils, therefore, of the driftless area are much less complicated than those of the glaciated region, but the driftless topography in general is much the more complicated and becomes a factor of equal or even greater importance than the soils in its influence upon the farming of the region. A study of the relation of topography to agriculture in LaCrosse county, typical of the Wisconsin driftless area, forms the basis for this thesis.

The first step in the study consisted in getting the facts of topography into workable form, and as concrete figures are much more satisfactory in such a study than any general statement or even a description, however minute, data were collected during the progress of a soil survey of the county which enabled a setting-forth in tabular form of the relative facts of topography of the different parts of the county.

This work consisted in an estimation, from the soil map and in the field, of the percentages of land representing the chief topographical features,- 1. The Rough, stoney land,- 2, The Wooded land,- 3, The Wet land,- and 4, The Steep land.

These estimates were made for each section of land separately, the whole being summarized later by townships and towns for comparative analysis.

The Rough stony land consists chiefly of the limestone outcrops and their talus slopes, together forming the rims of the many small v-shaped valleys which, with the wide valleys of the Black, LaCrosse, and Mississippi rivers comprise about two-thirds of the total area of the county.

The Steep land comprises the lower slopes of these same valleys and includes all land of from 10 to 20 degrees slope, most of which can be cultivated to some extent, but upon all of which some precaution must be taken to prevent destructive erosion while under cultivated crops.

The Wet land includes all the land which suffers from the periodic or permanent presence of too much water preventing profitable cultivation. This land is confined entirely to the valley portion of the county and consists largely of the present flood plains of the three larger rivers, the LaCrosse, Black and Mississippi.

The Wooded land includes all portions of the level upland and of the steep land ~~place~~ which have not been entirely cleared of their original timber growth. The wooded, non-arable wet land has not been included in these estimates.

Neither an extended description of the location, agriculture and topography of the county as a whole nor a description of the seventeen soil types recognized by the Soil Survey has been attempted here because these have been extensively treated in the Soils Report for the county and duplication would not accomplish the purpose of this thesis.

The general purpose has been to study the agriculture of the county in relation to its topography; to present the problems encountered, ascertain what relation if any, exists between topography and distribution of crops, and to discover by means of such a study what lines of improvement may be suggested in the further development of the agriculture of LaCrosse county and the driftless area in general.

The thesis divides itself into four parts:-

A. A discussion of the agriculture of the county by provinces as shown by the accompanying map.

B. A presentation of the larger distinctive problems of farming in the area.

C. A comparison of the soil and crop resources of the county with the resources of similar areas in the United States mapped by the Bureau of Soils.

D. An analysis of the average farm of the area; its resources, production, export and final conclusions as to lines along which farming may be expected to improve.

CONSTRUCTION OF THE MAP

The map accompanying this report was drawn with the idea of putting in graphic form, data for LaCrosse county which cannot well be shown on the regular soil map and much of which must otherwise remain more or less inaccessible within the mazes of a note book constructed day by day as the work progresses in the field.

With this idea in mind, the percentage of rough-stony, steep, wooded and wet land for each square mile of land in the county have been placed along the left hand side of each section on the map. The distribution of the underlying magnesian limestone is shown by a system of close dotting, the rest of the county, undotted, is underlaid by the Potsdam sandstone formation.

To represent the various types of farming practiced, and at the same time to show the distribution of soils grouped according to the agricultural value and type, the county has been divided into provinces based largely on the distribution of soils and partly on the kinds of farming carried on. These Agricultural Provinces are shown by a system of coloring on the map and the soils and agricultural practice of each are described in a short written description which

begins this report.

It was hoped in the beginning, also, to show some relations between topography and the distribution of the different kinds of crops within the different towns of the county. While this was not entirely successful, it is believed this work has been of value in viewing the agriculture of the county from a somewhat different angle than is customary in a soil report.

Upland and Valley Province.

This province includes the eroded upland peneplain, underlaid by the Lower Magnesian Limestone formation which has been cut by stream work into deep and mostly steep-sided valleys leaving irregular narrow ridges between them. The limestone is underlaid at 150-200 feet by the Potsdam sandstone which outcrops at lower levels especially on the eastern and northern edges of the county and has thus contributed toward the formation of the valley soils only.

The portion of the province in the north half of the county lying between the LaCrosse and Black River systems has been extensively eroded, and but a narrow band of limestone capping the divide is left. The tops of the main ridges are but one-quarter of a mile wide and the outlying

lobes much narrower. South of the LaCrosse River the ridge tops are wider and much more cultivatable land remains upon them. Middle Ridge, the main east and west divide between the LaCrosse River and Racoon Creek drainage systems is in many places from one-half to two miles wide on top.

The limestone capped ridges run mainly east and west, the secondary drainage going down the sides to the north and south into the main east and west flowing streams. The valleys average $\frac{1}{4}$ to $\frac{1}{2}$ mile wide. Springs are numerous. Fish, Dutch, Smith, Bostwick and Mormon creeks carry the drainage.

The valleys and most of the ridges are cultivated, and though much rough stony land is found, this southern part of the province is one of the most fertile and most thickly settled parts of the county. The soil of the ridge tops is of loessial origin, being a grayish to buff colored silt loam five to twelve feet deep. This silty upland soil has been washed down the slopes making them less steep and spread over the sandy valley bottoms making them most fertile.

North of the LaCrosse River erosion has been more extensive, the valleys are wider, the Potsdam sandstone is in

greater evidence, and but a small amount of limestone ridge top is left. The main dividing ridge extends east and west into the county about five miles north of the LaCrosse River. The secondary lobes extending south of the main ridge are generally low and narrow, sandy or stony and mostly wooded. To the north they are more abrupt and descend to the wide Lewis Valley in which Mindoro is situated. North of Mindoro a low, rolling, silty, largely wooded ridge one to two miles wide divides the Lewis Valley from the sandy Black River Valley which borders the north edge of the county.

Dairying and general farming are carried on in this province. Grains, corn and hay are the chief crops. Butter, cheese, milk and hogs are the chief exports. Pasture is generally good. Silos and manure spreaders are in common use. Erosion is one of the largest problems of the province. there being a large area of steep and rough stony land. The laying out of fields and the harvesting of crops, the building of roads and transporting of products have also been made difficult for this reason.

The Garden and City Supply Province

The area included in this province is intended to indicate the more immediate portion of the county upon which LaCrosse city depends in part for its food supply, and to include most of the farms which derive all or some portion of their income directly from products supplied to the city. The province is not confined to any one soil type, but includes several types. some of which are especially adapted to truck farming, others not so well adapted, but utilized because of nearness to market and other reasons.

The province includes two areas having different soils and producing somewhat different products. One includes the alluvial sands of the Mississippi River valley surrounding the city and a portion of French Island and part of the sand terrace bordering the river between Onalaska and La Crosse. The finer sandy loam parts of this area are specially adapted for truck farming and are highly developed on these lines.

LaCrosse city is built upon a level sand terrace at the base of the bluffs. This terrace, several square miles in extent was originally treeless and called Prairie La-Crosse. It was described in 1854 as being fertile next to

the bluffs, giving large crops of corn, oats, wheat, vines and roots; "the central portion is less fertile, being of a dark color, not very movable, rather close, easily cultivated and yielding fair returns". Near the river the sand was said to fly with the wind and required much manure.

Elevated 20 to 30 feet above the river, it is now largely occupied by the city and but a small amount south of the city is cultivated. The yellowish to dark brown sand here lies in low wavy ridges and hollows. Corn, melons, rye and some garden truck are grown. The small stream leaving State Road Coulee is diverted and used to irrigate some of the sandy soil. Here a small area of fine alfalfa, clover and corn are grown (Sec. 16, R 7, T.15). In general, this sand is too coarse for trucking and is not intensively cultivated. A strip of black silt at the base of the bluffs is very good, but is of small extent.

French Island north of the city (R.7T.16) is elevated 15 to 30 feet above the Mississippi River and Black River which enclose it. The cultivated portion of the island includes about four square miles. Most of it is coarse, dark brown sand with an occasional appearance of gravel. Including a large part of the southwest corner of the island

is a fine sandy loam which is the truck portion of the island. This was originally timbered, the rest of the island having been grass-covered prairie. Less than a dozen farms produce the truck furnished to the city. Berries, fruit, cabbage, potatoes, beets, peppers, squash, cucumbers, melons, lettuce, etc. are grown. The products are hauled by team to the city. Corn yields 50 to 70 bushels; oats 25 to 40 bushels; wheat 20 bushels, depending much on the character of the rainfall. Southwest of Onalaska sections nine and ten are ~~also~~ extensively given over to truck crops also..

The second and larger portion of the Garden and Supply province extends east and southeast of the city and includes the bluff slopes, coulees, and upland ridge tops. On the lower slopes and at the base of the bluffs facing the Mississippi River, many small farms raise fruit and vegetables. Grapes and apples are grown on some of the steep, protected slopes of the draws. Chickens, ducks, honey, cabbage, tomatoes and potatoes are produced. Farther east and south on the wider ridge tops and in the valleys, grain, corn and clover are the staple crops; potatoes, berries, etc are grown for the city. Dairying becomes more and more the main type of farming. LaCrosse, being the only accessible

market draws its supplies from a great distance in this direction. Potatoes, butter and milk are brought to the city from 10 to 12 miles distant. Dealers in the city collect milk, paying $3\frac{1}{2}$ cents per quart at the farm.

The Black Silt Valley Province.

This Province includes about 45 sections of valley lands (32,000 acres) largely in the central part of the county, bordering and tributary to the LaCrosse River. Detached areas of the black silt in Lewis valley between the towns of Mindoro and Stevenstown and east and west of the town of Holmen are included.

West Salem is situated near the center of the largest part of the province which includes the richest and longest cultivated soils of the area. A number of valleys among which are Adams, Burns, Bostwick, McKinley, converge to form with ~~the~~ part of the LaCrosse River valley, this sloping or level fertile district. The topography is level on the valley floors, with gentle slopes leading down to them from the enclosing hills and ridges. Practically none of the province is wooded. Its primitive cover was grass prairie or scattered groups of trees known as ^{oak} ~~vals~~ openings.

The black silty soils were largely deposited in quiet water where the level of the Rivers was much higher than now. The material is reworked or secondary loess derived from erosion of the upland, deposited on an originally sandy valley bottom, and given a large content of organic matter derived from the decay of plant growth upon it while in a wet condition. The original sandy character of the valley is shown by sand beds beneath the present silty soil and by bars of sand which rise to the surface or approach it beneath the silty layer. These bars are found near the present stream bed only which is the lowest part of the valley where probably the greatest volume of water has always flowed and less of the light silt being deposited.

Two dark silty types of soil were recognized; one a recent alluvial terrace type, the other a slightly more elevated and lighter colored gentle slope type representing either an older alluvial terrace or a soil due to some colluvial action. The latter soil occupies the slopes between the recent alluvial terrace and the bluffs which enclose the valleys. The fertile valleys were the first portions of the area to be extensively settled, and farmed. The numerous brick houses and excellent farm buildings at-

test the fertility of this province. Early reports give yields of 105 bushels of wheat and 75 bushels of oats per acre. The latter yield is still duplicated in favorable years.

Corn is the most valuable crop, yielding 60 to 80 bushels per acre. This is nearly all fed to stock. Little is sold. Cereals are apt to produce excessive growth and lodge in consequence. Sugar beets are becoming a valuable crop, 15 to 20 tons of the roots being grown per acre. A factory at Janesville supplies the seed, (paid for by the farmer), a man to thin out and weed the fields, and pays \$5 per ton for the beets. Many small plots of from 2 to 10 acres of beets are grown, mostly in the eastern half of the province. Wheat was formerly the largest crop and still yields 25 to 35 bushels per acre, but is now but little grown.

The canning industry and intensive forms of agriculture will develop in this province as corn, peas, berries and all truck crops grow well. A large factory recently built at West Salem is intended for the canning of peas. Dairying is the most general type of farming. Silos are numerous. Many hogs are fattened. Creameries at West Salem, Baile Mills, LaCrosse, Holmen, Mindoro use most of the milk produced in the province.

Slough Province

This province includes the low lying bottom land bordering the rivers of the county, the most of it lying along the Mississippi River. This broad river flood plane two to three miles wide is divided in two portions by the wedge-like LaCrosse Prairie which extends from the Bluffs on the east to the river channel.

The portion of the slough province south of LaCrosse city is mostly a heavy grayish mottled clay or sandy clay. Extensive flat sand knolls and bars elevated 2 to 10 feet above the surrounding surface are found near the south county line where the bottom is widest. These sand areas are cultivated in small patches most of them being much cut up by shallow slough channels and water holes. Most of the heavy mottled soil is underlaid by sand at from 10 to 30 inches with coarse gravel at three to six feet.

Willow ~~brush~~ ^{grove}, birches, elms, soft maple and a few oaks are the principle trees. Much of the southern part had but few if any trees, and as far as known, was always clear. Rushes and marsh grass cover the heavy soil and where hay is not cut yearly, weeds grow thick and tall, fertilized by the deposit left by the frequent floods. North of Onalaska the

slough county is wet, has more of the old channels, many with water in them continuously, and nearly all of it is more or less densely wooded.

Generally all of the bottom except the highest sand knolls is inundated several times yearly for periods of from three to thirty days. Inundations occur both in fall and spring depending largely on the character of precipitation at the head waters of the river. Several houses are located on the highest level sand areas and these are often cut off by water; travel to market being by barge and boat during high water. Large amounts of hay are cut on the heavier portions and stored in sheds and stacks. Only the level sand bars are cultivated. Corn, grass, rye, potatoes, mels, etc. are grown here. The best hay and corn are produced in wet years. The land sells at from two to ten dollars per acre. Little good timber is left. An artesian well on one of the sand areas in Sec. 28, T.15 was driven 450 feet deep.

The type of farming best adapted to the southern part of this slough province seems to be some form of grazing and fattening of cattle. North of Rice Lake most of the bottom is so continuously wet and filled with channels that little use can ever be made of it in its present condition. Grass growth is abundant after the floods. Sand knolls conveniently

located serve for the location of buildings, growing of corn for hogs, garden, etc. Large areas of from 300 to 500 acres are necessary to carry on such a type of farming profitably as much of the land is too wet or too sandy for good grazing. Elevated knolls must also be included in the farms in order that stock may find refuge and forage during floods.

One objection, is the necessary isolated character of this farming and the difficulty of communication during large portions of the year.

The Sandy Soils Province

This province includes the sandy soils of the county. Residual sands from Potsdam sandstone and alluvial sands of several types of varying grades of fineness and of various degrees of agricultural value.

Portions, the largest of which lie north of Onalaska and also bordering the Black River on the north edge of the county, have been driven into wavy dunes or knolls and ridges most of which are thinly wooded. This is the poorest sand in the county, especially that bordering the Black River.

The residual sand from Potsdam sandstone is found on steep slopes at the base of some of the bluffs and forms long gentle slopes at the ends of secondary lobes of sandstone which project down from the higher limestone bluffs

and ridges above. Finer and loamier portions yield 30 to 40 bushels of corn in wet years, though the type is affected by drought in dry years. Corn and rye are the main crops. Sod is maintained on the best portions only.

The alluvial types are three, based on degrees of fineness. The finest, a fine sandy loam is found only in isolated patches of from 40 to 700 acres on the upper terraces bordering the rivers. Corn and all cereals grow well on it. Good pasture and clover can be maintained on it. This type is the natural truck soil of the county and is so used southeast of Onalaska and on French Island. German people are very successful in this gardening and the land sells at from \$50 to \$150 per acre.

The medium sandy loam is found in level extensive areas east of Bangor and west and north of Burr Oak bordering the rivers. With proper methods this soil produces 40 to 60 bushels of corn and fair oats and barley in favorable years. The soil withstands drought well and sells at from \$18 to \$35. In connection with bottom land for pasture it makes a fairly good soil for dairy farming.

The coarsest of the alluvial sands is found bordering the Mississippi River. It is a medium to coarse brown sand with yellowish subsoil, frequently gravel at 24 to 40

inches. The type is generally poor, subject to drought and produces fair yields of corn and rye only in most favorable seasons. This sand is found on French Island, Bryce's Prairie and on the terrace north of Holmen bordering the river. This soil sells at from \$10 to \$15 per acre.

General Problems of Farming.

General Problems.

1. Erosion.
2. Moisture.
3. Rotation.

Under this head it is proposed to discuss some of the problems of a general character which are to be encountered in LaCrosse county in particular, and in all of the counties of Wisconsin in general which border the Mississippi River. These problems are largely those of topography and have had a large influence upon the development of agriculture in these counties.

One of the most important problems of the counties bordering the west side of Wisconsin is due to their topography. Their drainage development has produced an intricate system of valleys cut deep into the original peneplain. This system of steep sided^{VALLEYS} with level to rolling limestone ridges between has given to much of this part of the state a more or less great percentage of rough stony land comprising the cliffs and steepest rims of valleys, and much steep land subject to erosion, lying largely in somewhat gentler lower slopes which lead down from the bluffs and valley sides to

their bottoms.

As shown by the topographical data collected for LaCrosse county and summarized on the accompanying map, about one-sixth of the total area of the county needs special care to prevent erosion and loss of the soil covering while under cultivation. This land is distributed along the sides and slopes of the valleys and ravines cut into the limestone up-land of the east two-thirds of the county. Excepting in the broader river valleys of the Black, LaCrosse and Mississippi Rivers which total about 180 square miles, or one-third of the county, there are very few farms in the county which do not include a greater or less amount of land of this steeper kind. Even in the southeast corner of the county where the widest ridges abound, few farmers can carry on their operations without some attention to the problem of erosion. Illinois Station Circular 119 shows that this problem is important also in the river border counties of that state. Erosion in LaCrosse county is of two kinds. The most extensive is that of sheet erosion and ditch formation on valley sides and sloping land. The other kind is the ditch formation and removal of fertile bottom soil due to a regrade of the valley bottoms themselves.

The former type of erosion is prevalent on the up-land loessial soil which is a light colored silt loam with

generally heavier subsoil occupying the slopes and limestone ridge tops and designated Knox silt loam on the soil map. The development of erosion is here due to the removal of the forest growth from ridges and slopes. Soil had been carried down ridge tops to the valleys for ages, but the timber covered slopes as found when settlers first came represented an equilibrium between erosive forces and the causes which tend to create and keep a soil covering upon this land. And in this equilibrium a large factor was the forest cover which, being removed allows the erosive forces a new lease of life until another equilibrium is established, which generally means either a complete removal of soil or the great reduction in value of the slopes for agricultural purposes.

In spite of the danger of complete loss of soil, an excessive amount of these slopes have been cleared and cultivated, and the amount of steep land cultivated will increase as the value of the land increases. Theoretically, as the amount profitably expended in erosion preventive measures depends upon the value of the land, and as the expenditure demanded increases with the steepness, there is a limit to the slope which can be cultivated under present conditions. This limit of slope has been variously estimated at from 10 to 20 degrees (Glenn U.S.G.S.) (Prof. Paper 72)

Other factors are the kind of soil and cultivation and the amount of water coming down over these slopes. In general, sandy and stony soils resist erosion best. The more water the soil can absorb, the less the amount of water which must run down the slope and do the eroding. Cultivation is safe only up to the point where excessive amounts of water must get away over the surface. Thus at the head of a ravine where surface water from the ridge top converges from all directions toward the ravine, cultivation is dangerous at a much more gentle slope than on the ridge slope or valley side where a strip of woods protects the lower land from the run-off of the higher slopes.

In the second or valley-bottom type of erosion, the destruction is due to a lowering of the water course which may be a dry run or intermittent stream or a constantly flowing stream. This sort of erosion and removal of the soil of valley bottoms though not so extensive as the slope erosion is often very destructive and sudden in its accomplishment. A deep ditch may be formed in the middle of the bottom, or the black surface soil may be removed in the smaller ravines and valleys leaving stony or gravelly and nearly useless flats in its place. The sandy terrace of the broader valleys and slopes with a sandy subsoil are peculiarly liable to this ditch formation. Most of the destruction is

done during hard, sudden storms when the volume of run-off is greatly increased and the valley bottoms become soaked with water.

Most of the preventive methods now in use in the county consist in adapting the crops to the slope. The steeper slopes and rough stony land of the highest parts of the valley slopes are usually left covered with trees. This upper belt of trees if of sufficient width is a very efficient protection for steep slopes below it. The effect of the forest cover consists first, in making the soil more porous and absorbent by the penetration of its roots; second, by preventing collection of water into ditches and rivulets, and by breaking the force of the downpour, much of the rain running from the limbs and down the trunks of the trees; and third, the organic matter, covering of leaves, refuse, etc., increases the absorptive power of the soil. The belt of trees not only breaks the force of the rainfall and surface flow, but absorbs the rain and releases it gradually by seepage, thus acting as a reservoir of moisture for the cultivated slope below.

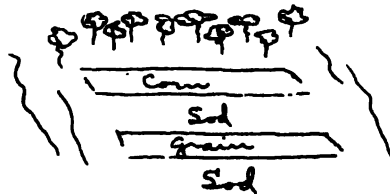
In clearing land for cultivation, the clearing is usually begun near the valley bottoms on the gentler slopes and proceeds up to the higher and steeper parts. Thus the

protective belt of trees above becomes narrower and less efficient until it cannot take care of the surface flow and ditches begin to form on the cultivated land below. Right here the farmer should cease removing the trees and brush, put the upper part in sod and allow his forest belt to increase again till he may safely plow the lower slopes. Many places were seen where ditches past all repair had developed on slopes with no protecting belt of trees above, where opposite slopes equally steep have been long cultivated without excessive erosion because protected above by trees.

Next to the belt of trees in effectiveness, is the laying down of the eroded slope into timothy whose sod holds the soil in place. This effectively prevents ditch formation, but on the steeper slopes thus put into sod, but one crop of hay at most can be obtained when the land becomes covered with red-top, blue joint, or inferior grasses and weeds which must be pastured off. Good pasturage is found for from four to six weeks in spring, and the grass is kept short. Then a dry spell comes and the slopes become brown and dry; cattle must seek pasture on the moister valley bottoms, and the uncultivated sloping part of the farm becomes nearly valueless for the rest of the year. Such steep slopes might be more permanently useful and profitable if

left to scattered timber growth with underbrush cleared away. Some such slopes left in trees were seen giving pasture through the entire summer and into fall, meanwhile serving as the farm wood lot as well.

But there are other slopes which admit of cultivation without too great erosion if but part of the slope be plowed any one year. Many such slopes can be put into crops and hay in alternate strips at right angles to the slope.



And often this method of cropping was seen in actual practice. The sod above the crop served to spread and absorb the surface run-off and the sod below stops the growth of ditches and catching any eroded soil and run-off from the cultivated strip. Shallow drainage channels or ditches already started, if left in sod often serve to retard erosion on the gentler slopes.

In the stream erosion of valley bottoms prevention of damage and control of water is often more difficult. If a fall be produced at the mouth of the small valley, the stream wearing through its bed of black, clayey soil into sandy or loose gravelly beds beneath, the headward movement of the fall may be very rapid or slow, but in either case

hard to arrest. The surface being undermined, the fall works its way up the valley leaving a deep ditch in its wake in which the water then flows at a lower level.

These ditches grow very slowly and then may work their way back suddenly a mile or two during a hard storm. In this way farms are cut in two, fields spoiled and the bottom cut into two narrow strips even in danger of caving into the deep ditch during a storm. Bordering some of the larger valleys are terraces and in sandy valleys are sand flats where eroding water from the sandy slopes drops its load on the level bottom. Many such terraces and flats are covered with a layer of more recent silty or loamy deposit which with the sandy subsoil may be twenty feet or more deep.

In such a place the stopping of an upward working fall is very hard and often almost impossible to stop. The water falling from the harder surface layer at the head of the ditch into the new channel ten or fifteen feet below, undermines the loose sandy subsoil. Huge blocks and masses slump into the ditch and the unsupported surface follows. The fallen sandy material in the bottom disintegrates beneath the falling water and is carried away to make room for more. Often tributary ditches work back from the main

ditch to the valley sides cutting into fields and roads. Often the road must be changed or expensive bridge work done to pass the ditch. Such occurrences are most frequently seen in the sandy Black River valley and in some of its tributaries.

Preventive measures adopted are often laborious and expensive. A masonry wall is built across the ditch or it is completely filled with brush, stones, and logs to hold the material carried by the water. Where the eroded material is silty these methods often succeed and ditches large enough to hold buildings become gradually filled up behind the dam. But in sandy material, to stop such a ditch once started is a much harder matter. Instances were found where farmers had put more than \$100 in labor and material into an attempt to stop one ditch. No amount of straw, brush, logs, stones, hay, manure or any other filling seems able to stop some of these ditches. The fine subsoil sand passes through the most carefully constructed thatch, or the ditch is cut around any dam placed across it.

The most successful attempt at stopping the ditches in sandy soil consisted in directing the flood water above the ditch into a board flume or apron built like a toboggan from the head of the ditch to its bottom. The water is

collected into the flume by a board dam whose wings converge at the flume. If the water can be kept to the flume till a good thick patch of willows planted in the ditch bottom under the flume has obtained a good foothold, the danger of continued growth is lessened and other methods such as a plank or stone wall or other filling can usually be depended upon to stop the ditch with the help of the willows.

II. The Moisture Problem.

It might seem an exaggeration at first thought to make the assertion that there is a moisture problem in humid Wisconsin and that lack of water is a factor in the limitation of yields possible in fertile soils in a region having more than 30 inches of annual rainfall. Yet an observance of many poor hay fields, short thin stands of oats and general droughty appearance of crops on some parts of the upland ridges of LaCrosse county in late summer, together with the difficulty experienced in getting a good catch of clover here in dry years, have suggested that moisture conditions may have much to do in limiting crop yields.

The most obvious method of arriving at a conclusion on this subject is to determine the amount of water avail-

able for plant growth per acre after all other avenues of loss of rainfall have been taken into account. Data from the Weather Station at LaCrosse indicates that the average rainfall (annual) during the past 32 years has been 31.31 inches and that the greatest variation from this amount is from 8 to 10 inches and the average variation 4 to 8 inches. The largest part of the rain comes in the growing season during the months of May, June, July, August and September, there being from 3 to 4 inches fall during each of these months. There is an average of ten days in each of these months when more than .01 inches of rain falls, so that distribution of the rainfall in time and amount is most favorable.

Now what becomes of this total supply of moisture? How much do the crops get? How much could they use? Rain fall is lost from the soil in three ways, principally by evaporation from the surface and from plants, by surface run-off and by drainage or seepage to under ground water and thence to the ocean. The proportion of this rainfall used by plants depends upon many factors of which we consider the most important to be:-

- I. Character of the season.
- II. Kind of soil. Character of rainfall.
- III. Adaptability of plant.
- IV. Cultivation, - disposition of crop, etc.

Each of these factors is important and has its bearing upon the size of crop produced and the consequent amount of water necessary. It may be stated as obvious that the same amount of water on the same soil will not produce the same yield in different localities, neither will equal crops be produced in the same locality on the same soil in different seasons.

I. Character of Season. Aside from the amount of total rainfall and whether the season be humid or dry, there are other factors of seasonal variation. The temperature produced by a large number of days of sunshine may be such as to produce great loss of water by evaporation one season and less the next. The amount of wind has great effect on the rate of loss of water from soil and plant. King found that amount of sunshine has a large effect on the evaporation from the plant. In cloudy weather and at night, plants lose but little water, while in bright sunshine there is marked loss from plants even in air saturated with moisture.

II. Kind of soil. Character of rainfall. It is plain that in a coarse porous soil more water is needed to keep the surface moisture supply adequate than is needed in a fine soil of large water-holding capacity, because there is less loss by percolation in the latter. Very small showers

of rain even though they come daily are of little value to plants. Such rains only destroy any previous soil mulch and induce greater evaporation from the surface after the rain. Sudden, large down-pours with long intervals of dry weather between are equally unfavorable. Every season and locality has a greater or less amount of rainfall of this character.

III. Adaptability of the Plant. It is common knowledge that some plants grow in arid regions where others cannot grow. Some crops require more moisture than others. Also some plants adapt themselves to conditions so that drought-resisting species are developed which produce larger yields on small rainfall than other kinds can.

IV. Cultivation and Evaporation Preventives. One of the aims of cultivation is to prevent waste of soil moisture. Maintenance of a mulch minimizes evaporation and conserves fall and winter rains for crops in the growing season. Fall plowing and addition of manure aim to enable the soil to catch and hold the rains by increasing the water-holding capacity of the soil. Disposition of the crop, whether it shades the ground or exposes most of it to wind and sun also influences the amount of moisture lost by evaporation.

Before considering the actual amount of water lost by evaporation we will briefly approximate the losses of rainfall by the other two avenues,- percolation and run-off.

A. Percolation or drainage water. That a large part of the annual rainfall is lost by seepage or drainage to the water table and then to the streams is indicated by a table compiled at the Rothamsted Experiment Station, England, showing the average drainage for 12 years from a bare field.

Month	Rainfall	Drainage
Jan.	2.13 in.	1.93 in.
Feb.	2.16 "	1.74 "
Mar.	1.7 "	.94 "
Apr.	2.25 "	.79 "
May	2.48 "	.79 "
June	2.59 "	.78 "
July	2.85 "	.62 "
Aug.	2.69 "	.76 "
Sept.	2.70 "	.82 "
Oct.	3.12 "	1.68 "
Nov.	3.20 "	2.32 "
Dec.	2.34 "	1.88 "
Total		
Jan.-Dec.	30.21 "	15.05 "
May-Aug.	10.61 "	2.95 "
Sept.-Dec.	11.36 "	6.70 "

Here it is shown that half the rainfall passed out through the drains. It will be noticed that the drainage is greatly reduced in summer as compared to fall due to greater loss by evaporation in summer. The loss is as high

as 80% in winter and low as 20% in summer. It is true that this loss by drainage would have been much less if a crop had occupied this field during the growing season, but it is nevertheless plain that a large part of the rainfall on well-drained upland soils is lost by seepage into the sub-soil.

B. Surface Run-off. Newell of the United States Geological Survey in computing the average portion of rainfall which runs away to the ocean, reaches the conclusion that:-

1. 48.9% of the rainfall upon the Savannah River Basin flows to the ocean.

2. 56.5% of the rainfall upon the Connecticut River Basin flows to the ocean.

3. 53% of the rainfall upon the Potomac River Basin flows to the ocean.

These are averages for from 6 to 13 years and include both surface run-off and percolation losses by rainfall. Mosier (Ill. Cir. 119) estimates that the following amount of rainfall is lost in the rough country counties so far mapped by the detailed soil survey of that state.

Districts	Rainfall	Run-off	%
North	33.48 in.	14.5 in.	43%
Central	38.01 "	19.0 "	50%
Southern	42.19 "	23.0 "	54%

From the foregoing measurements and estimates, it maybe reasonably stated that from 45 to 50% of the rainfall gets into the streams and is not available for plant growth in ordinary cultivated districts of rolling topography.

C. Losses by Evaporation from Soil and Plant. Many experiments have been conducted to determine the water lost by evapoartion and in growing a crop, and results vary with the conditions of the experiments. But in general it has long been known that in few localities is the rainfall of such a character as to allow of the largest crops being grown of which the best soils of the locality are capable . (King, Drainage and Irrigation.) Hellriegel states that in most cases a continuous supply of water equal to one-half the soils' capacity gives the largest crops, that even short droughts reduce yields largely, and that the rainfall at Dohme, Germany, (55l.m.m.).without considering losses , is barely half enough to support his maximum crops grown in his experiments.

Prof. F. H. King of the Wisconsin Experiment Station did much careful investigating of the moisture problem. His results of several years' work are given in

the 8th Annual Wisconsin Station Report and in his book, "Irrigation and Drainage." The experiments were carried on with oats, barley, corn, clover, potatoes, peas, both in the laboratory and in field plots.

Two corn plots in the open field producing 9.727 pounds and 9,840 pounds of dry matter per acre were found to have used 17.76 inches and 17.99 inches of water from the surface four feet of soil. He summarizes his results in the following table.

King's Summary of Water used by Plants.

	Number :Trials	Lbs. water :used per lb: :dry matter	Water :used :inches	Per acre :Dry mat- :ter pro- :duced tons	Acre inches :of water per :ton dry mat- :ter
Barley	5	464.1	20.69	5.05	4.096
Oats	20	503.9	39.53	8.89	4.447
Maize	52	270.9	15.76	6.59	2.391
Clover	46	576.6	22.34	4.39	5.089
Peas	1	477.2	16.89	4.009	4.212
Potato	14	385.1	23.78	6.995	3.399
Ave.		446.3	23.165	5.987	3.939

More plants per square foot and therefore greater yield per acre was grown in the cylinders than is practicable in the field. This tended to enlarge the total amount of water used (ave. 23.165 inches), but loss by run-off and percolation were entirely prevented in the laboratory and this cannot be done in the field. King's laboratory

results compare very favorably with his field plot tests.

The results show that from 16 to 40 inches of water can be utilized by large crops in Wisconsin. Oats and clover are shown to be able to use the largest amounts of water and would therefore be the first to suffer for lack of water in time of drought.

King also estimates the available rainfall in Wisconsin for crops during the ten year period 1887-1897.

Mean rainfall during growing season of	Barley	Oats	Maize
Loss by percolation and ineffective showers.	11.5 in.	13.25 in.	15 in.
Inches Effective Rainfall	8.65 "	10.19 "	12.014 "
If used as effectively as in the Plant House, this water could produce the following crops.	40.29 bu.	64.99 bu.	71.5 bu.
Average crop for Wisconsin	24.6 "	34.4 "	33.7 "
LaCrosse County			
1905: Washington Township	31. "	28. "	35. "
Greenfield "	31. "	32. "	43. "

These figures show that ^{no} more than 8 to 12 inches of rain are available for crops in Wisconsin and that these crops could use 23 inches of rain.

The estimated yields possible if this available rainfall were used as effectively as was the case in King's plant house experiments, compare well with the yields ex-

pected in most favorable years on fertile soils in Wisconsin. These latter estimates were made for level lands, and have not taken into account the great losses of rainfall by run-off on steep and sloping land. In LaCrosse county where two-thirds of the land is in valleys and valley slopes and a scant one-third is ^{ridge-top} ~~upland~~, and where 25 to 40% of the land has a slope of from 10 degrees to 45 degrees, it may easily be seen what a large part of the rainfall is lost by direct run-off. And the relative advantage of valley and upland soils is very marked in respect to available moisture in such a country as this.

Comparison of Valley and Ridge land in Respect to Moisture conditions.

I. Depth of soil and levelness. The alluvial valley ~~s~~ilts are level and though often having sandy or gravelly ~~s~~ubsoil are generally many feet in depth so that they are ~~b~~est able to absorb all the rain which falls. The soil of ~~t~~he narrower ridge lands on the other hand is much more ~~s~~hallow, varies from 5 to 10 feet in some places and one to 3 feet in others lying on solid limestone.

Very little of the ridge, also, is really level, for though it may be from one-fourth to three-fourths miles

wide on top, complicated systems of drainage depressions, all more or less steep, unite to carry off the rainfall to the valleys. These drainage ways reach back covering nearly all of the upland ridge land and very few ^{Fields} miles are perfectly level.

II. Evaporation. The ridges have also much the best opportunity to lose what water they have because fully exposed to the full power of the sun and winds. Elevated 100 to 400 feet above the valley bottoms, the difference in evaporation due to wind is great. The higher slopes and valley sides are so exposed also. The black alluvial soils have the advantage of their great organic matter content in holding moisture and of protection from wind.

III. Water table. Another difference notable in the moisture conditions of valleys and ridges is the nearness of the water table or source of permanent water supply to the surface in the case of the valley soils. Few valley fields are more than 15 to 20 feet and most no more than 3 to 6 feet above the stream level.

The ridge soils however, lie on limestone rock which may be but from 2 to 10 feet beneath the surface. Flowing water for wells is found here only at from 50 to 250 feet down, and in dry years only the deeper wells give water the year round. The valley soils have all the advantage

of location for good moisture conditions, besides receiving the run-off from the slopes. Indeed in most years, the alluvial soils (except the sands) receive too much water. Large portions are often flooded or kept too wet to plow. On the valley soils, the best yields of grains and corn are produced in dry years. In normal season this black land is often "too rich", excessive straw growth is produced and the grains tend to lodge in consequence.

The moisture problem is one of the upland portions rather than of the valleys and chiefly a problem of the steep land phase. On the slopes the problem is a double one,- that of holding enough moisture, and preventing erosion at the same time. Some of these slopes now cultivated are too steep to resist erosion and until we are ready to terrace or to practice deep, contour plowing with cover crops and plenty of manure added, should be kept in permanent pasture.

Often this pasture would give better service if the trees were left standing, for trees are a great aid in holding the rain and preventing loss by evaporation under influence of wind and sun. This protecting effect of trees is shown by Ebermeyer's experiments in Bavaria where he found that evaporation from soil was more than six times greater in bare fields in summer than in adjoining woods.

Average for one year from open dish.

36 cubic inches of water evaporated in woods while,						
100	"	"	"	"	"	" open field.
429	"	"	"	"	"	" woods. Summer. }
1223	"	"	"	"	"	" open field. " }
111	"	"	"	"	"	" woods. Winter. }
314	"	"	"	"	"	" open field." }

It is believed the foregoing sketch will serve to show that the lack of sufficient water for crops may be a very serious problem upon all the upland, steep and poorer sandy parts of the county.

III. Rotation of Crops.

While rotation of crops is not a problem peculiar to this part of Wisconsin, nor are the rotations so far developed and practiced peculiar to this area, nevertheless a consideration of the development and history of rotation, its objects and benefits, may well precede a statement of rotations in LaCrosse County.

History. The rotation or alternation crops is one of the oldest established principles of agricultural practice. One of the first things man discovered when he began growing crops in any one place, was that he could not grow the same crop continuously on the same spot without an eventual decrease in the yield. The easiest and most natural solution of this problem where there was plenty of land was to grow the crops in a new place, letting the old one cover itself again with natural vegetation. The next discovery was, that the abandoned piece of ground regained its former productive power after a time, and might again be put in crop.

These discoveries produced the first great crop rotation, one which served its purpose so well that it is practiced even today in some of our more backward countries. The growing of corn, tobacco or cotton among the blackened and girdled trees in some parts of the south and subsequent

abandonment of the exhausted field are remnants of this first rotation process.

It is stated that the modern rotation idea originated in the Teuton village communities where the collective ownership and cropping of the land developed the three year rotation:- fallow, wheat, beans or oats,- and that this rotation idea was carried thence to England by the Romans. The early Jewish law also commanded the Israelites of ancient times to let the land "enjoy her sabbaths" every seven years. Thus the basis of this rotation was the fallow year, a rest for the land. Fallow comes from the word "fealewe" (brown or red) to describe the color of the bare land. Among the Scots and Normans as well as the Teutons the fallow or rest year developed from the prolonged rest of ten or fifteen years after exhaustive single cropping, into a system of continuous cropping, but of rotation with crops with a regularly recurring year of rest.

The first fallow, called bare because the land was left idle and untouched for the year, developed into the cultivated fallow. It having been found that cultivation increased the good results of fallowing, it became the practice to plow and cultivate the land as often as six or eight times during the fallow year. The cultivation minimized the weed problem as well as producing better crops

than the bare fallow.

Soon after the cultivated fallow came the idea of a soiling or cover crop to cover the land during the fallow year. Having found that turning under the weeds which grew on the bare fallow land helped it to "rest" or recuperate, and that frequent cultivation had a still greater good effect, it was natural to seek the benefit of both these processes. So the farmer cultivated the fallow land part of the summer, grew the cover crop in the fall, and turned it under to feed his wheat next season.

The next great step in the advance of cultural methods was the extended use of clover in the rotation. The fallow had been highly developed. Gradually the idea of rest for the soil was replaced by the idea of change of crops as a basis of the preservation of soil fertility. Clover was introduced into the cropping system of England in the early part of the 17th century. The turnip crop was largely introduced in the same century. With the increase in population and value of land, the fallow became increasingly expensive and the loss of a year's crop harder to bear. Clover and turnips began to take the place of the fallow year in England. The clover improved the texture and nitrogen conditions of the soil, and the turnip crop being heavily manured and thoroughly cultivated,

these crops readily crowded out the expensive fallow year and came to be called the "fallow crops". It is estimated that from two to two and one-half million acres of roots, (turnips, mangles, sweeds) are now grown and fed in England annually.

The introduction of clover developed the common six year rotation,- fallow, wheat, clover,; fallow, wheat, beans (or oats) and with the increased use of turnips the famous Norfolk's four year rotation was evolved. This rotation originated in county Norfolk, England, and developed on lands of the lighter class and consisted of the crops,- turnips, barley, clover, wheat. It is here interesting to note that fallowing was little or not at all practiced on rich alluvial soils. The Egyptians also developed no crop rotation system on their fertile delta and valley soils. Permanent improvements in soil management develop on the less fertile soils. This is probably due to their greater extent and to the fact that the need for improvement is felt first and most on the less fertile soils.

Rotation,- Objects and Benefits. The four year rotation of which the Norfolk was the fore-runner has become a popular one and with variations of crops due to climate, locality, etc. has been widely used.

As previously noted, the rotation idea had its origin in the discovery that sooner or later soil became tired under single cropping, that a rest was necessary, and finally that good farming with rotation of crops accomplished this rest as well as did the fallow year. The farmer having discovered the fact, it became the part of the scientist to discover why rotation is a benefit.

Liebig advanced the theory that plants removed from the soil, take with them plant food which is not replaced by natural processes and that the soil is therefore permanently poorer by the amount of food removed with the plant.

DeCondolle thought that toxins or plant secretions poisonous to succeeding crops of the same plant might account for the final failure of the single crop system.

Which of these views or what view is correct has not as yet been settled, but the general principle is established that all cropping impairs soil fertility and that rotation of crops helps to defer or avert soil sterility. Why does rotation help to defer or avert soil sterility?

1. It has become known by analysis of crops that, though all plants need a certain number of food elements for growth, that different plants use these foods in different proportions. So that the continuous growth of one crop tends to remove one or more plant foods faster than

the others. One of the objects, then, of rotation is to have a series of crops such that the food elements are removed uniformly from the soil for as soon as one element of food is completely removed, crops will not grow though the other elements be present in abundance.

2. Different crops have different root systems feeding in different zones or depths of soil. So here again, rotation seeks uniform food removal by alternating deep rooted, subsoil-feeding crops with shallow rooted surface feeding crops.

3. It has been found that certain crops grow best after certain other crops and that the treatment necessary for the production of one crop prepares the soil peculiarly well for some other certain crop.

Other objects and benefits attained by rotation of crops are:-

4. Preservation of good soil conditions:-

a. By weed control. Certain weeds afflict certain crops and become most obnoxious and harmful where the one crop is continuously grown.

b. By maintaining good soil texture. Intertilled crops alternate with untilled and deep cultivated with shallow cultivated crops helps to keep all of the soil section porous and in good tilth.

c. By maintaining nitrogen and organic matter

in soil. Most cultivated soils are lacking in organic matter in most favorable amount which is lost by cultivation and crop removal and returned by legume growing, green manuring, fertilizing, barnyard manure, etc.

d. By controlling diseases and pests. Certain fungus and bacterial diseases afflict certain plants as (smuts, and rusts) and are kept down by alternating with crops on which they cannot grow.

5. Equalization of labor on the farm. Provision of proper kinds and succession of food for stock. Rainfall, and temperature, altitude, soils, exposure of the farm, money crop of the locality all have thier influence upon the kind of rotation adapted to any farm.

Thus the determination of the rotation best for any location is a complex problem, and no amount of theorizing can fix the exact balance between all these factors in any specific case. A theoretical rotation which may take into consideration all the known factors and which may conform to the most approved general rules of good farming is of no value if the average farmer cannot actually and easily carry it out on his particular farm .

If this statement of the case be correct, the most reliable source of information as to improvement of farm-

ing in any area would appear to be obtained from the experience of ^{the} best and most successful farms in that area. Information, also should be obtained from the experience of farmers in other areas of the same approximate conditions and soils as the one under consideration. With this idea in mind, it is proposed to continue this report under the two heads:-

1. The Knox Silt Loam Farm in the United States.
2. The Average Farm of LaCrosse County.
 - a. Tendency of past farming in the county.
 - b. Utilization of fields and crops.

The Knox Silt Loam Farm in United States. The pre-dominating soil types of LaCrosse County is that of the east two-thirds or upland portion of the county. This type of soil has been mapped in adjoining areas and neighboring states by the United States Soil Survey, and has been given the general name Knox Silt Loam. The following is a condensed statement of important parts of the summary by Bonesteel of the conditions reported in the Knox Loam areas mapped by the Bureau of Soils.

1. Soil . The Knox Silt Loam is a light yellowish loess soil found chiefly along the greater drainage systems

of southwestern Wisconsin, East and Southern Iowa, Missouri, Nebraska, southern Indiana, Illinois and Kentucky.

Originally a timbered soil, it occupies rolling to steep ridges and sloping land.

2. Limitations in use. Crop adaptations vary with its rainfall in different parts (25 in. to 40 in.) and with its topography. Erosion is the chief problem. In general all sloping portions should be left in forest or in permanent pasture. The soil is adapted to corn, grass, grains and potatoes. Its silty surface easily eroded, and its dense subsoil with lack of organic matter limit its use as a corn soil. Drought often hurts corn on it in late summer. It is a good grain soil in the north. In the south (Ind., Ky.) corn and oats are not so much grown - more winter wheat. In the west (Nebr.) corn, prairie hay, and alfalfa are grown.

Special crops are few. Tobacco has been grown on it in Wisconsin, Illinois, Indiana, Kentucky. Little incentive for extension. Orchards grown extensively on it in Missouri. Strong apple trees and early fruit of fair quality are produced. Apple and fruit raising could well be extended in Wisconsin, Illinois and Iowa. Best growth on slopes bordering streams. Varieties adapted. Wealthy,

Jonathan, Winesap, Winesap, Ben Davis, Gano, Red Astrachan.

Extent of Occupation. Eighty per cent of level areas are cleared. 15% or less of the steeper phase is cropped. Local areas allowed to go wild because of erosion. Some still in prairie grass in Nebraska.

3. Improvement and Crop Adaptations. On the more level portions the greatest improvement would be, :-

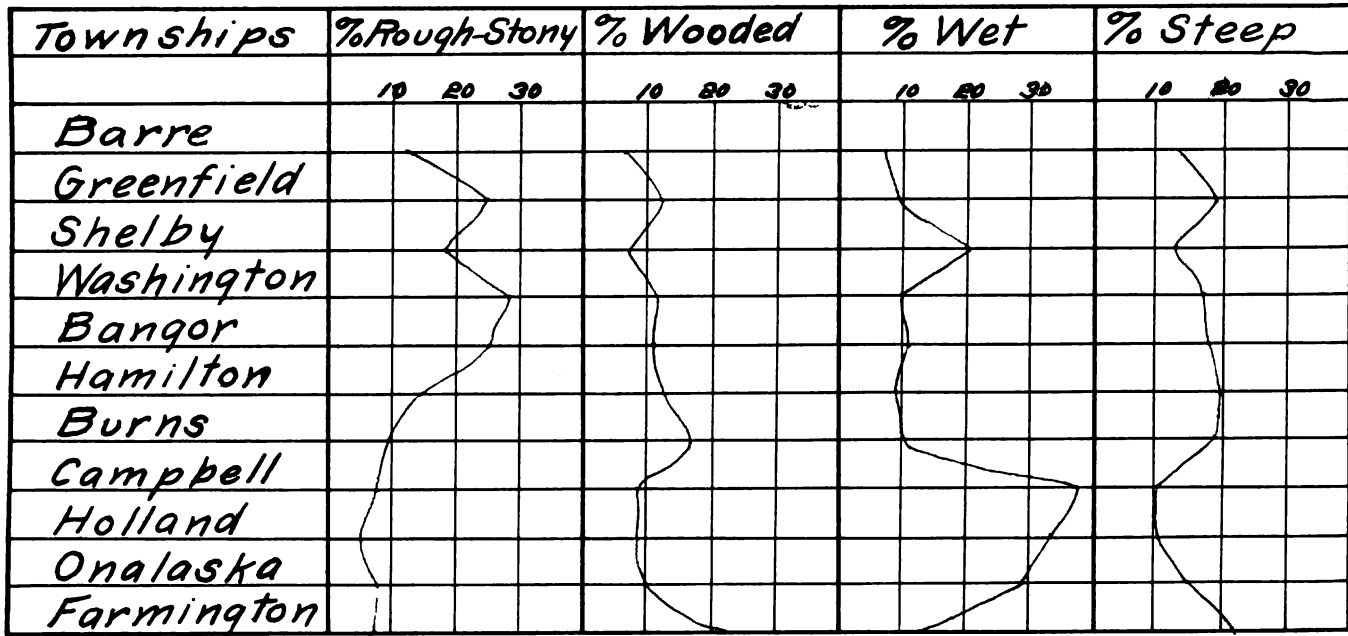
A. An increased organic matter content.

B. Rational and definite crop rotation practice.

Corn and often grains should not be grown on sloping parts. Corn gives a high average yield, but amount of land put in crop is limited by topography. Physical characteristics of soil limit it to corn, grain, grass. Corn, oats, grass are the order of crop acreage in the north. Alfalfa is grown extensively in Nebraska. Potatoes and binder tobacco are good crops.

In dairying sections, crop production has been increased much beyond the average for the type.

CROPS and TOPOGRAPHY OF LACROSSE COUNTY Soils



CROPS



The above table is an attempted graphical comparison of the topography and of the crops grown in the year 1905 in the different towns of the county.

As will be seen, the percentage of each town occupied by the different crops is remarkably uniform and the curves produced seem to bear little if any relation to any of the topographical curves. The method of comparison may possibly be somewhat at fault, but the natural conclusions from these tables is that the amount of rough stony; wet or steep land in the several towns has no great effect upon the relative amounts of oats, barley, corn or hay grown, or that other factors such as soils and location have greater influence. However, in a general way the following statements seem to be borne out.

1. The most hay and oats are grown in the roughest and steepest towns.

2. The most barley is grown in the roughest and steepest towns.

3. The least corn is grown in the roughest and steepest towns.

The Average Farm. 153 acres. LaCrosse County.

Soils and topography.

Valley land 2/3

Ridge top 1/3

Rough stony, -----10 acres

Wet-----26 "

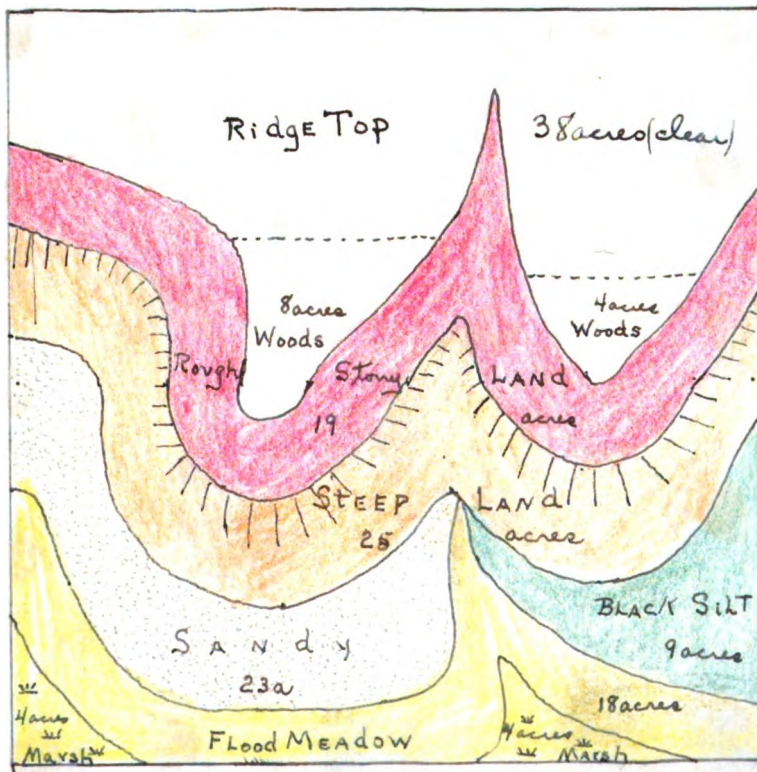
Steep-----25 "

(Wooded)-----20 "

Black soil----- 9 "

Sandy soil-----23 "

Ridge top-----50 "



In order to view the problems of the LaCrosse county farm from another angle and to facilitate the use of census figures as well as the data shown on the accompanying map, this part of the report is constructed on the basis of the Average Farm.

It is possibly unfair to draw conclusions for a portion of the state or for the county itself from the viewpoint of the averages. While admitting that this average farm is a myth, that it does not exist, and that few actual farms have as many different kinds of land in anything like the proportions here given; still it is believed that the problems and resources of this average farm are in part those of every actual farm and farmer in the county. It is true that there are many farms of the level Black Silt soil only; others consisting of the sandy and flood-meadow soils alone and some having only the level to rolling ridge land with no steep land problems. Yet these farms comprise but a small part of the county and by far the greatest part of the farms include a greater or less amount of the steep, rough stony, and valley or ravine bottom land.

The percentages of different kinds of land for the average farm are obtained by summary of the percentages for

each section of land in the county as shown on the map. The data used in estimating the crops, exports, stock, etc. of the average farm were obtained from State and Government census reports.

The Average Farm of LaCrosse County is divided as follows.

There are 1811 farms reported in 1910 which average 153 acres in size.

Land	Acreage	Use
Rough Stony land	19	Pasture and woodlot.
Steep land	25	1/2 pasture and grain, 1/2 wooded.
Sandy land	23	Corn and rye chiefly.
(Wooded	20)	Pasture.
Wet	26	1/2 hay. 1/2 pasture.
Black silt land	9	Corn and grains.
Cleared Level Ridge Top	38	General farming.

Crops	Acreage	Live Stock
Corn	11	Milk cows----12
Oats	15	Other cattel- 2
Barley	8	Horses----- 4
Clover	.4	Hogs-----15
Hay	10	Sheep----- 5
Wheat	2	Poultry-----61
Potatoes	.7	
Total hay and forage	16	
Rye	3	

Utilization of Land and Crops on the
Average Farm.

Farm Layout. The large percentage of rough stony land and steep land on the average farm not only produces a large unimproved area on the farm, but greatly increases the problems to be met with, i.e. erosion, moisture loss, and laying out of fields and the introduction of a rotation system. Planning a Model Farm is of little practical value except in that it illustrates and incorporates the prin-

ciples involved. In such topography as is found on this average farm and in LaCrosse county, every farm must be a model to itself. In planning a new farm or changing the system of an old farm, the general rules observed are:-

1. Arrangement so as to save time and labor in reaching all parts of the farm.

2. Provide for rotation of crops.

3. Provide sufficient food in kind and amount for the stock to be kept; and the plan adopted should, -

A. Be adapted to the kind of farming to be tried.

B. Make best use of soils and exposure of fields.

C. Provide a proper proportion of wooded to open, tilled to untilled land, and of annual crops, meadow and pasture.

Other desirable features are straight fences and roads, long cultivated rows, attractive appearance, etc.

Thus a model plan for a 160 acre dairy and hog-raising farm is given by Spillman (U.S.D.A.) follows:-

Two rotations are suggested.

			12	12	
17	11	14	2	2	11
			2	2	
12		5	7	5	
17			12		

- 1
1. Corn
2. Oats
3. Wheat
4. Timothy & clover
5. " "

For the 17 acre fields.

- 2
1. Corn
2. Oats
3. Clover
4. Timothy & clover
5. " "

For 12 acre fields.

G. W. Hewey's Model Corn Belt Farm includes:-

Corn-----40 acres.

Meadow-----40 "

Pasture-----40 "

Ce reals----30 "

But such planning as this obviously cannot be applied to the LaCrosse county farm. More often the rotation must depend entirely upon the topography for often corn can only be grown on certain select level places on the ridge farm or barley must be oftener grown than oats because of drought conditions on slopes or narrow ridge tops.

In order to arrive at some general conclusion as to the efficiency of the present farm management system, it is proposed to make the following comparisons on the Average Farm.

1. Crops (am't.) grown and stock supported.
2. Crops and Arable land.
3. Stock supported and land area.

I. The Crops of the Average Farm and the stock supported.

What part of the crops grown are used by the stock?

What is sold from the farm as the "money crop"?

By applying the balance sheet used by Spillman, (Bureau Plant Industry, Bulletin 102) of the Department of

Farm Management (U. S. D. A.) to our average farm, we will determine how much food must be raised to support the stock kept on this farm.

It is assumed that all stock are furnished with pasture, that corn silage is produced at the rate of 9 tons per acre, hay 1 1/2 tons per acre, and that one acre of pasture with 5 pounds of hay and 20 pounds of corn fodder daily will keep one cow from May 10 to Oct. 10. (Summer season.)

Cows-----12.

May 10-Oct. 10 - 1 acre pasture (2nd year timothy and clover) per head. 5 lbs. hay per head.

Aug. 10-Oct. 10 - 20 lbs. silage or corn fodder per head.

Oct. 10-May 10 - Average ration, 40 lbs. silage, 10 lbs. hay, 4 lbs. grain.

Yearlings-- 2.

May 10-Aug. 10 - Silage 25 lbs., hay 15 lbs., grain 4 lbs.

Aug. 10-Oct. 10, - Fodder 25 lbs. hay 15 lbs., grain, 4 lbs.

Oct. 10 - May 10, - Silage 30 lbs., hay 18 lbs. grain 4 lbs.

Horses----4

Average ration, 18 lbs. hay, 6 lbs. grain daily.

Hogs--- --15.

Clover hay 2 tons, pasture 5 acres, grain 15 tons.

	Silage	Hay	Soil ing	Grain	Pasture
	Tons	Tons	Tons	Tons	Acres
12 cows	51.12	4.5	8.0	5.11	12
2 yearlings	2.2.	1.5	1.5	.5	
	6.4	1.0		.24	
4 horses		3.8		.85	
		13.2		4.4	5
6 hogs					
9 pigs		2.0		15.0	5
5 sheep					3
Total	59.72	39.0	9.5	26.1	25
Yield per acre	8	1.5	5	.85	
Required acres	7.5	26.	1.9	30.	25

Acreage required for stock kept.	:	Actual acreage grown
Corn silage --- 7.5 acres	:	11 acres
Hay-----26.0 "	:	26 "
Soiling----- 1.9 "	:	.4 " clover
Grain-----30.0 "	:	28.0 " oats, barley wheat rye.
Pasture-----25.0 "	:	25 " steep land.
Total-----90.4 "	:	90.4 "

From the foregoing tables it is seen that all of the crops grown are needed to support the stock kept and that therefore the "money crop" consists in the stock and dairy products sold.

These conclusions comply with the facts for practically no corn and very little grain is sold from La-Crosse county farms, dairy products and stock sales making up most of the income of the farmer.

II. Crops and arable land. Is all of the arable land of the average farm utilized? Could more crops be grown and thus more stock supported? A comparison of the land available for cropping with the crops actually grown as shown by the census should give some light on these

questions.

Average LaCrosse Farm

Dry level land		Crops.
Ridge top-----	38 acres	Corn-----11 acres.
Black Silt-----	9 "	Hay-----26 "
Sandy-----	23 "	Grain-----28 "
Total-----	70 "	Total-----65 "

This table tends to show that practically all the level land of the average Farm is now cropped. Therefore any increase of cropped area must be obtained from the , (1) Steep land, (2) Small wooded ridge-top areas, and (3) Flood-meadow or wet land.

Increase of cropped area.

I. In the discussion of the erosion problem it was shown that increased cultivation of the slopes depends upon the increase in value of land. Nearly all of this land is now cultivated that can be with present methods. Deep plowing and heavy manuring, and contour plowing may increase the amount some. Terracing will not be practiced till the land is much more crowded with people than now.

II. The level wooded ridge-top is small in extent, amounting to but 5% to 8% of the land and much of this

must be kept for wood-lots.

III. Drainage of any great part of the wet land will involve large expenditure in preventing floods along the larger streams. This cost will be prohibitive for a long time. Thus only a small part of these unimproved lands can be improved for many years to come.

III. Stock supported by the Land.

With the present efficiency of the level land, and assuming that the pasture land is good enough so that one acre supplemented with fodder and silage can support one cow, only 90 acres of land are needed to support the stock kept on the average farm as shown in the comparison of crops and stock. This would leave 60 acres of the farm unaccounted for. In other words, if this land is used largely for pasture, 85 acres of the farm do service as pasture where only 25 efficient pasture acres are needed to support the stock. Even though the rough stony land of the Average Farm (19 acres) and marsh (8 acres) be subtracted as useless even for grazing, 59 acres of land are still left for pasture.

There is, therefore, room for increased efficiency of the pasture part of the farm. The art of producing good permanent pastures on sloping land is not known or prac-

ticed here as in European countries. Sheep could find pasture also on much of this land which is not of much value as cow-pasture.

Average Farm exports. In order to know what the future farming of LaCrosse county will be like it is necessary not only to know what the present farming is, but the direction or tendency of farming to the present time should be known. The experience of the past should be expected to guide the development of the future, and future improvements would reasonably be supposed to follow lines of improvement followed in the past.

It is generally agreed that present farming in Wisconsin is much better than the systems practiced 30 years ago. In general, farming has developed from exclusive grain raising to stock raising, and finally to butter and cheese production. Wisconsin is now one of the leading dairy states. The reason generally given for the superiority of present over past farming is that more stock is kept on the farms and more manure is put on the land now than formerly.

The following tables constructed from census reports represent an attempt to show the change in production of the average farm of LaCrosse county and to show that

this better farming of today is due to an actual reduction of the amount of plant food sold from the farm. The first table shows the amounts of the principle products of the average farm for the years 1910, 1905, 1885, 1870. The data are obtained from the United States and State Census reports, the total amounts for the county being divided by the number of cultivated farms reported for the year.

Average Farm products.

	1870	1885	1905	1910
Crops				
Corn , bu.	137	347	340	343
Oats, "	203	413	920	503
Barley "	18.7	73	132	129
Wheat "	474	168	50	22
Rye "	15	39	24	36
Stock No.				
Cattle	7	12.5	13	14
	(3 milch)	(10 milch)	(11 milch)	(12 milch)
Horses	4	3.5	4	4
Hogs	2	24.3 (12)	30.5 (14.5)	30 (15)killed and sold
Sheep	7	8	6	5

This table shows the transition from grain farming to dairying at least in a general way. It will be seen

that there was a great increase of corn, oats, and barley in 1870 to 1885 with the increase of stock kept on the farm. Wheat, however, the great "money crop" of the grain farming days, declined with the increase of stock kept on the farm.

The number of milch cows increased from 3.5 in 1870 to 12 in 1910. The number of hogs produced has steadily increased. But this does not explain why present farming systems are better than former ones. In the following tables, a comparison of the export of plant food from the average farm is attempted.

The estimates of plant food, (phosphorous, nitrogen and potash) sold are based on percentages given in Warrington's "Agricultural Analysis", and from tables to be found in Hopkin's "Soils and Permanent Agriculture.

Average Farm Export of Plant Food.
in L.A.C.

1905	1640 Farms	Lbs.		
Cattle and calves sold and consumed	5 -----2300#	N	P	K
Hogs-----	14.5 -250#-3600#	53.4	37.9	4.14
Sheep & Lambs----	1.8-----180#	63.3	24.8	5.4
Tobacco-----	91.0#-----	3.5	2	.13
Milk-----	8320.lbs., (1040gal.)----	10.	1.7	10.
Butter-----	1747. lbs.-----	50.	15.	12.
Cheese-----	296.5 "-----	4	1	.5
Wheat 50 bu. not exported.		17.5	6	5.1
Lbs. Total		201.7	88.4	37.27

1885	1582 Farms	Lbs.		
Cattle and calves sold and consumed.	-----2.5	N	P	K
Hogs-----	12.3 at 250#	16.1	10.5	1.26
Sheep and lambs-----	2.0	52.8	20.7	4.5
Cheese-----	86.4#	4.0	2.0	.3
Butter-----	300.#	5.2	1.05	1.2
Tobacco-----	7.7#	.6	.15	.06
Wheat-----	168.0 bu.	.1	.001	.1
Potatoes, 78 bu., Oats 413 bu., Corn 347 bu. not exported.		255.0	39.0	43.0
Lbs. Total		33.38	73.41	50.42

1870	1394 Farms.			
		N	P	K
Cattle and calves sold and consumed,- 3.2 milch :Not 3.7 other :Export- ed.				
Sheep----- 2.0		4	2	.3
Swine----- 3.1		12.3	4.83	1.05
Wheat----- 447.0 bu.		639.0	108.0	117.0
Rye ----- 15 bu.				
Corn----- 137 "	Probably			
Barley----- 18.7 "	not ex-			
Oats----- 203.0 "	ported.			
Total		655.3	114.83	118.35

	Lbs. Loss	N.	P	K.
1870-----		655	115	118
1885-----		334	73	50
1905-----		202	88	37

Such tables as the above are subject to errors in the Census reports in reporting the number of farms. The reports of the yields and stock by the State Census in 1905 and the United States Census of 1910, however, agree very well as will be seen in the first table. The statement of the kinds of export is arbitrary, except in that it is certain wheat was formerly the chief money crop, whereas, hogs and dairy products are now sold and little grain or corn leaves the farm.

All kinds of grain as well as corn were sold more extensively formerly than at present, and these are not included in the export for 1870, so that the differences in amount of plant food leaving the farm then and now are probably much greater even than the tables would show. No data were available to show the amounts of plant food returned in feed bought on the farm, but in general the LaCrosse county farm produces and uses its own fodder and grain.

These tables then, serve to show that the change in farming has meant a progressive saving of plant food to the average farm by a decrease in the export of products high in these elements, and a substitution for them of other products which do not reduce the soil food supply nearly so rapidly. These figures indicate that a saving of at least 300% in nitrogen and potash has been effected by the change of farming in this county and in the state.

Another thing which the tables would seem to indicate, is that the saving of phosphoreous has not been nearly so effective as is that of the other two elements, nitrogen and potash. If this is true, it means that phosphoreous is not being conserved as well as the other elements and that it is likely to be the first of the three mineral

fertilizers needed if resort to such fertilization ever becomes necessary in western Wisconsin.

"Better farming, better business, better living" is Roosevelt's summation of the rural life problem. "Application of modern science to agriculture,..... of commercial methods to the business side of farming,..... the building up of a domestic and social life which will withstand the attraction of the modern city", are the same thoughts in different words by Sir Horace Plunkett in his essay on the "Rural Life Problem of the United States."

The lines along which Better Farming may be accomplished in LaCrosse County as indicated by the foregoing study may be summed up briefly as follows:-

I. Improvement of Land and its use.

A. Steep land.

1. Making of better pasture land by use of greater number of varieties and better adapted varieties of grasses.

2. Utilization for production of fruit and pasturage of sheep.

3. Extending cultivated portion by means of, (1) Contour plowing, (2) Deep plowing and heavy manur-

ing, (3) Possibly terracing.

B. Wet land.

1. Drainage in favorable locations.
2. Putting it to use to which it is adapted as pasture, hay-growing, stock raising, etc.

C. Black land.

1. Production of special crops with tendency toward more intensive farming on this fertile land. Sugar beets; potatoes; crops, as peas and corn, for canning.
2. Drainage in some places.

D. Sandy land.

1. Use of crops adapted . Increased use of vetches and soiling crops.
2. Improvement of organic matter content.

E. Ridge land.

1. Increased growth of clover in rotation. Use of lime to promote clover growth.
2. Rational and definite crop rotation. Special crops, fruit and potatoes.

That the factor of good management and proper adaptation of farming to conditions is greater than that of type of soil is shown by the fact that successful farms

are found on practically all soils, good and poor alike. Agricultural Surveys (Cornell Bul. 302., U. S. D. A. Bureau Plant Industry, Cir. 75) have shown the following facts to be true in the areas studied.

1. That the most successful farmers are not as a rule following methods of farm practice different from those of the unsuccessful, but are utilizing their land and equipment to much better advantage.

2. That the farmer's profits are increased by increased years of schooling, by increased capital invested, and that the large farms pay better than the smaller ones.

3. That the most successful farms have more diverse sources of income than the average, do the greatest amount of business, and keep the most cows and buy the most concentrated feed for their stock instead of trying to raise all the feed used and selling few crops.

What good management may do in LaCrosse county is illustrated by the farm of Mr. H. W. Griswold just west of the town of West Salem, in the Garden and City Supply province described in the first part of this report.

I. This farm of 80 acres of black alluvial soil supports:-

60 cattle, 4 horses, 50 hogs.

A. Rotation:- Corn, oats, clover, (pasture) of which the first and third pay best.

B. Proportion of crops:- Corn, 30 acres; hay 12 acres; grain, 10 acres.

C. Exports:- Registered cattle, milk, hogs, pure bred seed, (oats and corn).

D. Mr. Griswold states that he has little trouble with clover and alfalfa although his black soil is acid to litmus. Failure with clover he blames to thin seeding and thick nurse crop chiefly. All grain for feed is bought.

The following table shows a comparison of the Average Farm with Mr. Griswold's Farm.

	Griswold's Farm	Average Farm.
Acres of level tilled land.	80	80
Value per acre	\$100	\$47.00
Accessory acres	—	72
Value per acre.	—	\$ 8.00
Value, total	\$8000	\$4336
Stock supported	64	23
Hogs "	50	15
Proportion of crops.		
Grain <i>acres</i>	10	28
Corn "	30	11
Hay "	12	16

The strong points in the systems of the above farm compared with that of the Average Farm are:-

1. The selling of only the best pure bred seeds and cattle.

2. The diverse sources of income and the buying of all concentrated foods needed.

3. This farm has the highest priced soil only, with no waste or uncultivable land.

The average farm uses all its arable land and supports ^(only) all the stock which the cultivated part of the farm will produce food for.

Improvement is to be found in (1) an increased and better use of the rough and steep and wet hay land, raising larger numbers of sheep and improved breeds of cattle; (2) in an increase of the number of sources of income by growing more pure seed grains, fruit and potatoes; (3) in an increased production by the development of better breeds of stock and better methods of soil management and use of improved varieties of seeds.

Phosphorous Determinations on Soil Ex-
perimental Plots.

Original

Plot VII.	Sub Plot A.	:	#1152-----	.21%	P ₂ O ₅
"	"	:	#1153-----	.21%	P ₂ O ₅
"	"	:	#1154-----	.22%	" "
"	"	:	#1155-----	.20%	" "
"	"	:	#1156-----	.19%	" "

Plot III.	Sub Plot A.	:	#1137-----	.089%	P 0
					2 5
"	"	:	#1138-----	.13%	" "
"	"	:	#1139-----	.15%	" "
"	"	:	#1140-----	.12%	" "
"	"	:	#1141-----	.12%	" "

Plot IV.	Sub Plot A.	:	#1142-----	.18%	P 0
					2 5
"	"	:	#1143-----	.13%	" "
"	"	:	#1144-----	.14%	" "
"	"	:	#1145-----	.16%	" "
"	"	:	#1146-----	.098%	" "

Phosphorous Determinations on Soil Ex-
perimental plots.

Original

Plot V. Sub Plot A.	: #1147-----	.091%	P O
	:		2 5
" " B.	: #1148-----	.13 %	" "
" " C.	: #1149-----	.12 "	" "
" " D.	: #1150-----	.22 "	" "
" " E.	: #1151-----	.16 "	" "

Duplicated work Gravómetric

Method. Crystalline Precipitates Only. Revised.

Plot VII. Sub Plot A.	: #1152-----	.14%	P O
	:		2 5
" " B.	: #1153-----		
" " C.	: #1154-----	.16%	" "
" " D.	: #1155-----	.16%	" "
" " E.	: #1156-----	.16%	" "


Plot III. Sub Plot A.	: #1137-----	.14%	P ₂ O ₅
" " B.	: #1138-----	.15%	" "
" " C.	: #1139-----	.15%	" "
" " D.	: #1140-----	.14%	" "
" " E.	: #1141-----	.13%	" "

Continued. Tables

Plot IV.	Sub Plot A.:	#1142-----	.5%	P 0
				2 5
"	"	B.:	#1143-----	.15% " "
"	"	C.:	#1144-----	
"	"	D.:	#1145-----	.14% " "
"	"	E.:	#1146-----	.15% " "

Plot V.	Sub Plot A.:	#1147-----	.16%	P 0
		:		2 5
"	"	B.:	#1148-----	.
"	"	C.:	#1149-----	.15% " "
"	"	D.:	#1150-----	.17% " "
"	"	E.:	#1151-----	.16% " "

The tables (fig. 1) show the arrangement of Plots Nos. 3, 4, 5 and 7 of the Soils Experiment Department. In 1907-08, a phosphorous invoice of these plots was made in order to determine the variation in amount of this element in different parts of the plots.

I. In each of the sub-plots a composite sample of twenty cores of soil taken in this manner  was

II. Two sub-plots selected for their wide variation in P O were re-sampled. Five cores taken one foot apart
2 5
in each sub-plot gave the following results.

		:Plot 3.Sub.A.:Plot 5, Sub. D.	
Percent P O in Core	1:	.14%	.20%
2 5	:	:	:
" " " "	2:	.09%	.21%
" " " "	3:	.14%	.22%
" " " "	4:	.13%	.19%
" " " "	5:	.14%	.17%
Av. of First Composite		.089%	.22%

III. A second composite sample of 10 cores distributed over each plot gave these results:-

Plot 3-----	.16%	P 0	Plot 5-----	.18%	P.0
		2 5			2 5
Plot 4-----	.16%	" "	Plot 7-----	.18%	" "

Good duplicates were secured in the first trial in all the above work excepting one case where a second determination was necessary. It was found necessary to add a

crystal of citric acid to clear up the NH_4OH solution of phosphomolybdate before precipitating with magnesium mixture. With the idea of duplicating this data and subsequently working out a thesis on the variation in phosphorous content in fields and in glaciated soils compared with residual soils, several of the samples which had been preserved, were again analyzed for P_2O_5 .

I. Great difficulty was at first encountered in getting the ammonium-phosphomolybdate to come down completely according to the official method. (Precipitation at 60 degrees and standing 24 hours.)

A. This was overcome first by precipitation with ammonia of the $(\text{Fe}, \text{Al}, \text{P}_2\text{O}_5, \text{etc.})$ from the nitric acid filtrate from the silica. The P_2O_5 being then precipitated as usual from a nitric acid solution of the above $(\text{Fe}, \text{Fe}, \text{Al}, \text{P}_2\text{O}_5, \text{etc.})$

B. At the suggestion of Mr. Truog, a complete precipitation of the ammonium-phosphomolybdate was secured by digestion on the water bath for from 1 to 2 hours and then standing over night. That the latter produced as com-

plete precipitation as the former method is shown by the following.

	Soil	Per cent P_2O_5		Original Determination
		Method A	Method B.	
Truog	1137	.152	.166 .159	.089
Dunnewald	1147	.17	.16	.09
"	1149	.162	.15	.12
"	1151			

The results so far obtained differed so often from those given in the original analysis (Table I) that it was thought that the first analysis might not represent the true conditions of the plots as to phosphorous content. Below is given a comparison of the results obtained by four people:- Dr. Peterson and Mr. Truog each analyzing a soil by the gravimetric method.

-- Per cent P_2O_5 --				
Soils	Original	Dr. Peterson	Truog	Dunnewald
1137	.089		.155 .152	.14
1150	.22	.17		.178
1147	.09	.157		.16
1154	.22			.16

From these results it seemed fair to assume that the average P₂O₅ content of the plots is from .15% to .18% and

that the variation shown in the original results must be due to the conditions and methods of determination. An attempt was made to find out what the cause of such variation of results by the gravimetric method might be.

1. A flaky Magnesium-ammonium-phosphate precipitate. Much trouble with flaky precipitates upon addition of the magnesia mixture was encountered. It was found that in general the flaky precipitate gives higher results than the entirely crystalline one.

The varying results obtained with flaky precipitates is shown below. In each case the pyro-phosphate of the first determination was redissolved by digestion with HCL in a beaker and reprecipitated with a slight excess of NH OH and a little Magnesia mixture.

Wt. of $Mg_2P_2O_7$ obtained (2 grms.)

Soil No.	Flaky	Not Flaky	Slightly Flaky	Original Results.
1137	.0070	.0037	.0066	.0027
1154	.0067	.0040	.0061	.0066
1152	.0056	.0042		.0064
1151	.0053	.0048		.0048
1149	P.0051	.0043		.0038
1143		.0046	.0043	.0040
1143		.0040	.0041	.0040
1141		.0030	.0033	.0032
				.0042

A comparison of the last column (Original Results) with the rest of the table shows that the original amounts of $Mg_2P_2O_7$ agree fairly well with the others, in some cases with the flaky precipitate, in others with the crystalline precipitate. This suggests that the flaky precipitate may have caused some of the high results in the original Table I.

The results in Table II are from crystalline precipitates which were obtained by filtering off any flaky precipitates, dissolving in HCL and reprecipitating with slight excess of NH_4OH . (F. A. Gooch & Austin, Am. Jour., Sci. Vol. 7, 1899, p. 187.)

Any turbidity resulting upon the solution of the yellow phospho-molybdate in NH_4OH did not re-appear upon reprecipitation of the phospho-molybdate in the official

way with but slight excess of molybdic mixture. This turbid precipitate(if soluble in citric acid) Hillebrand (U.S., G. S. Bul. 305) calls a compound of phosphorous which must be re-fused with carbonate to obtain the P_2O_5 . Olson believes it may be silica. (See Olson Grav. Anal.) The stain often acquired by the crucibles used in igniting the magnesium precipitates would indicate that this insoluble turbid precipitate contains iron and probably alumina. Careful washing of the yellow precipitate does not prevent the turbidity. Re-precipitation seems to do so.

Summary.

1. Plots 3,4,5,7 do not vary in P_2O_5 content more than .02% to .04%.

2. The variety of results indicated in Table I. are due to varying conditions in determining P_2O_5 . Low results may be due to incomplete phospho-molybdate precipitation; high results, possibly to flaky magnesium precipitates.

3. Good duplicate determinations are possible without their necessarily being correct.

4. Reprecipitation of the ammonium phospho-molybdate and the magnesium ammonium phosphate seems to offer a solution but makes the determination much longer.



A volumetric method in which the twice-precipitated phosphomolybdate is ~~titrated~~^{tit}rated with standard alkali and acid might provide greater despatch and equal accuracy.

Approved A. B. Whitson

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